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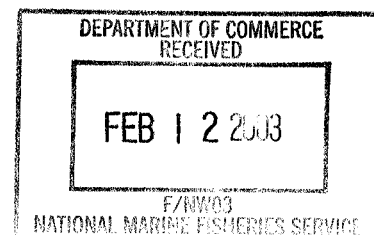
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February 10, 2003

Chief, Protected Resources Division
National Marine Fisheries Service
525 NE Oregon Street, Suite 500
Portland, OR 97232



Dear Chief of the Protected Resources Division,

I feel the scientific data support the NMFS's determination that the Eastern North Pacific Southern Resident Killer Whale population is below its Optimal Sustainable Population. Additionally, I support NMFS's proposal to designate this stock depleted under the Marine Mammal Protection Act.

Regarding the proposed rule, specifically Factors Affecting the Population, I have evidence that several infectious diseases warrant investigation as to their role in the decline of this population. As with many endangered and threatened wildlife populations, information about the role that infectious diseases may play in the decline of the southern resident killer whale population is not available. Consequently, the U.S. Biological Review Team (BRT) for Southern Resident Killer Whales (Kran et al., 2002) determined that due to lack of information, it was "not possible to estimate the probability that disease poses a major risk to the Southern Resident killer whale group." We recently evaluated the role that infectious diseases may be playing in this population's decline and their potential to negatively affect the long-term sustainability of this small population and identified 4 high priority diseases that warrant further investigation. This manuscript was only recently submitted to a journal for peer-review and the information was not available to the BRT for southern resident killer whales.

Please find enclosed a copy of the manuscript. As it is still under review, I ask that you keep it to a limited distribution and not cite the document. I strongly encourage you to consider infectious diseases as an additional factor that may be contributing to the decline of the southern resident killer whale population. I also ask that you consider that infectious diseases have the potential to threaten the long-term viability of this small population. More research is necessary to fully evaluate the role that infectious diseases play in both instances.

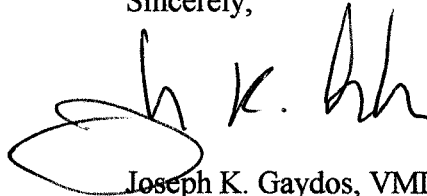


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NMFS should make every effort possible to further investigate infectious diseases in the southern resident killer whale population and use the results of this information to designate conservation measures to assist in providing protections to this population.

Please do not hesitate to contact me should you have any questions regarding this information. You may reach me by phone (360) 376-3910 or by electronic mail (jkgaydos@ucdavis.edu). Thank you for your consideration.

Sincerely,

A handwritten signature in black ink, appearing to read 'J. K. Gaydos', with a large, stylized loop on the left side.

Joseph K. Gaydos, VMD, PhD
Wildlife Veterinarian and Staff Scientist



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Evaluating Potential Infectious Disease Threats for Southern Resident Killer Whales,

***Orcinus orca*: a model for endangered species**

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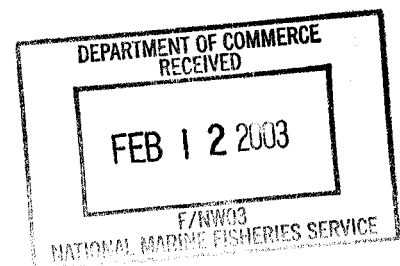
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Suggested Running Header: *J. K. Gaydos et al., evaluating killer whale diseases*



Abstract

Infectious diseases have the potential to play a role in the decline of threatened wildlife populations, as well as negatively affect their long-term viability, but determining which infectious agents present risks can be difficult. The southern resident killer whale, *Orcinus orca*, population is endangered and little is known about infectious diseases in this species. Using available reference literature, we identified 15 infectious agents (bacteria, viruses, and fungi) reported in free-ranging and captive killer whales, as well as 28 additional infectious agents reported in free-ranging and captive odontocete species sympatric to southern resident killer whales. Infectious agents were scored as having a high, medium, or low ability to affect fecundity or reproductive success, to cause disease in individual animals, and to cause epizootics. Marine *Brucella* spp., cetacean poxvirus, cetacean morbilliviruses, and herpesviruses were identified as high priority pathogens that warrant further study. Using identified pathogens to develop a standardized necropsy and disease testing protocol for southern resident killer whales and sympatric odontocetes will improve future efforts to better understand the impacts of priority and non-priority infectious agents on southern resident killer whales. This model can be used to evaluate potential infectious disease risks in other threatened wildlife populations.

Keywords: Endangered species, Infectious diseases, Killer whale, *Orcinus orca*, Wildlife Diseases

1. Introduction

Infectious diseases have the potential to negatively impact wild animal populations (Scott, 1988; Gulland, 1995; Deem et al., 2001), which has important implications for conservation (Young, 1994). Infectious diseases may play a role in the decline of threatened and endangered wildlife populations, as well as negatively affect population recovery (McCallum, 1994; Gaydos and Corn, 2001). Determining which infectious agents present a risk to a population can be difficult as these populations often are understudied from a wildlife health perspective, and potential disease threats may be unknown. The southern resident killer whale population (Ford et al., 1998), found within the inland waters of Washington (USA) and British Columbia (Canada), has declined 20% since 1996 (Krahn et al., 2002). This population, also called the eastern North Pacific southern resident stock of killer whales (Dalheim and Heyning, 1999), has been listed as endangered by the Canadian Committee for the Status on Endangered Wildlife in Canada (Baird, 2001). The U.S. National Oceanic & Atmospheric Administration - National Marine Fisheries Service recently reviewed the status of the population under the U.S. Endangered Species Act (Krahn et al., 2002). They concluded that the southern resident population was not considered a discrete population segment (DPS) as defined by the U.S. Endangered Species Act, however, if re-evaluation of the current global species taxon re-defines the southern resident population as a DPS, the southern resident population would likely be listed as endangered.

As with many endangered and threatened wildlife populations, information about the role that infectious diseases may play in the decline of this population is not available, nor is information regarding infectious diseases that may threaten the long-term viability of this small population. Consequently, the U.S. Biological Review Team for Southern Resident

Killer Whales (Kran et al., 2002) determined that due to lack of information, it was "not possible to estimate the probability that disease poses a major risk to the Southern Resident killer whale group." Despite the lack of knowledge, Baird (2001) notes that diseases "should be taken into account in conservation planning and population viability analysis" for the southern resident killer whale population.

We identify infectious disease threats for this population, and then evaluate them for their potential to be involved in the population's decline or to threaten the long-term viability of this small population. Identified infectious diseases serve as a baseline for developing a standardized necropsy and disease testing protocol for stranded southern resident killer whales and sympatric odontocetes. Additionally, the lists (Tables 1, 2, and 3) target specific high priority infectious diseases that warrant further study. This model may be useful in identification and evaluation of disease threats for other endangered or threatened populations.

2. Methods

2.1 Identification of pathogens in killer whales and sympatric odontocete species

Using available databases including Aquatic Science and Fisheries Abstracts, BIOSIS Previews, Current Contents, Fish and Wildlife Reference Service, and MEDLINEplus, as well as reference literature, we identified infectious agents (bacteria, viruses, and fungi) reported in both free-ranging and captive killer whales. Also identified were infectious agents not reported in killer whales, but reported in free-ranging and captive odontocete species sympatric to southern resident killer whales, specifically common dolphins (*Delphinus delphis*), Dall's porpoises (*Phocoenoides dalli*), false killer whales (*Pseudorca crassidens*), harbor porpoises (*Phocoena phocoena*), northern right whale dolphins (*Lissodelphis borealis*), bottlenose dolphins (*Tursiops truncatus*), white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), short-finned pilot whales (*Globicephala macrorhynchus*), and striped dolphins (*Stenella coeruleoalba*) (Osborne et al., 1988). Because probability of exposure is important in evaluating risk, the geographic location where the pathogen was reported was noted for all infectious agents reported in free-ranging species.

2.2 Evaluating possible pathogen involvement in the population decline of southern resident killer whales

Southern resident killer whale census data compiled by the Center for Whale Research (Friday Harbor, Washington, USA) and analysis of that data performed by the U.S. Biological Review Team for Southern Resident Killer Whales (Kran et al., 2002) were evaluated for mortality trends that could be related to an epizootic caused by an infectious

disease. Identified diseases also were evaluated and scored as a high, medium, or low ability to affect fecundity or reproductive success in killer whales.

2.3 Evaluating the potential of pathogens to negatively affect future population size and viability

Based on what was reported in the literature reviewed, identified pathogens also were scored as having a low, medium, or high ability to cause disease in individual animals (virulence in individuals) and to cause disease at the population level (epizootic potential). Pathogens for which virulence in individuals and epizootic potential were unknown were scored as "unknown." Where pathogens were reported from different species, from different locations, or described with differing virulence or epizootic potential, each reference was listed and scored accordingly. All infectious agents assigned as having a high epizootic potential were considered to have the potential to impact the long-term viability of the southern resident population.

3. Results

3.1 Pathogens identified

We identified 43 pathogens reported in captive and free-ranging killer whales or sympatric odontocete species, including 20 bacteria, eight viruses, and 15 fungi. Of these, two infectious agents were reported in free-ranging killer whales (Table 1), 13 from captive killer whales (Table 2), and 11 and 17 from free-ranging (Table 3) and captive (Table 4) odontocete species, respectively, that are sympatric to southern resident killer whales. Only two pathogens identified (porpoise morbillivirus and *Coccidioides immitis*; Table 3) were reported from the northeast Pacific Ocean.

3.2 Pathogens potentially involved in population decline

Since the annual census of southern resident killer whales was started in 1974, 78 animals have died. When evaluated by the number of deaths per year, death counts were the highest in 1998 and 2000 (7 per year), however no obvious epizootic patterns were noted (Fig. 1). Of the 78 deaths, 26% (n=20) were infants (0-3 years old), 14% (n=11) were juveniles (4-11 years old), 4% (n=3) were adolescents (12-17 years old), and 56% (n=44) were adults (>18 years old) (Fig. 2). When mortality was evaluated by age in years at death, only calves dying in their first year were over-represented (n=11), representing 69% of all infant mortalities (11/16) since 1978 (Figure 3). Supporting this, survival estimates calculated by the U.S. Biological Review Team for Southern Resident Killer Whales (Kran et al., 2002) found that calves dying in their first year and old males had the lowest survival rates. Because some diseases may preferentially affect calves born to first time (nulliparous) or second time (premiparous) mothers, life history data for mothers of southern resident killer

whale calves dying in the first year of life were evaluated by birth order to see if calves born to nulliparous, primiparous, or multiparous females were over-represented. No apparent trends were noted.

Of the 43 potential infectious disease agents identified, cetacean poxvirus was the only pathogen scored as having a high potential to cause neonatal mortality. Marine *Brucella* was the only pathogen scored as having a high ability to reduce fecundity or affect reproductive success.

3.2 Pathogens that may threaten the long-term viability of the population

No pathogen known to infect free-ranging or captive killer whales was scored as having a high potential to cause epizootics; however, such pathogens were identified in sympatric odontocete species and may have the potential to threaten the long-term viability of the small southern resident population. Specifically, morbilliviruses (dolphin and porpoise) and herpesviruses have high potentials to cause epizootics in several species of sympatric odontocete species and may have the potential to negatively affect the long-term viability of the southern resident killer whale population.

4. Discussion

Finding only fifteen infectious agents reported from free-ranging and captive killer whales exemplifies the severe lack of knowledge about infectious diseases in this species. Complete and standardized postmortem examination of all dead animals from threatened or endangered populations serves as an excellent first step in gathering information about infectious diseases in the population. Unfortunately, of the 78 southern resident killer whales

that have died since 1974 (Kran et al., 2002), carcasses have been recovered from only eight known southern residents (one neonate each from J, K, and L pods, J-4, J-18, L-14, L-51, and L-60) (Osborne, 1999; and unpublished data). Complete postmortem examinations were not performed on all recovered carcasses, and necropsy findings are scattered and difficult to find for the animals that did receive postmortem examinations. Our method of literature review for infectious diseases reported in free-ranging and captive killer whales, as well as in sympatric odontocete species, coupled with qualitative scoring of each agent for virulence in individuals, epizootic potential, and ability to reduce fecundity was the best method available for getting baseline information and evaluating the role infectious diseases may play in the decline of this population or in negatively affecting its future viability.

In long-lived species like killer whales, infectious diseases that affect fecundity or reproductive success could significantly impact the population's size and viability. Marine *Brucella* spp. are Gram negative bacteria closely related to better known terrestrial pathogens in the genus *Brucella* (Cloeckaert et al., 2001). Infection by *Brucella* has been documented to cause abortion in captive bottlenose dolphins (Miller et al., 1999); however, the clinical and pathologic significance of infection by these organisms in other marine mammals, including *Orcinus orca*, is not well understood. It is not known if marine *Brucella* infection occurs in southern resident killer whales, although antibodies to *Brucella* spp. have been identified in a free-ranging killer whale (Jepson et al., 1997) and were detected in a female transient killer whale stranded within the range of southern resident killer whale population (CA 189; January 2002, Dungeness Spit, Washington; pers. comm., S. Raverty). It is possible that killer whales within the southern resident population could be infected with marine *Brucella*, and the potential exists for this pathogen to cause abortion and decreased

fecundity in this population. More information is needed on the pathogenesis of marine *Brucella* in killer whales and southern resident killer whale exposure to these bacteria and further research is warranted. When the opportunity arises, all captive and free-ranging killer whales should be screened for antibodies to these bacteria, the placenta and tissues from all aborted killer whale fetuses should be cultured for the bacteria, and attempts should be made to isolate the bacteria or amplify *Brucella* nucleic acid from all stranded killer whales.

Like the southern resident killer whale population, many wild animal populations experience highest mortality in the first year age class. Reasons for southern resident calf mortality in year one could include poor mothering, infectious or non-infectious diseases, infanticide, or other causes. Cetacean poxviruses typically cause cutaneous lesions referred to as "tattoo" or "ring" skin lesions in odontocetes (Van Bressem et al., 1999). Reported clinical and epidemiological data do not suggest poxvirus infection causes high mortality in adult cetaceans (Geraci, et al., 1979); however it has been suggested that poxvirus infection could cause neonatal and calf mortality in immunologically naïve cetaceans (Van Bressem et al., 1999). Cetacean poxvirus has been documented to cause cutaneous lesions in killer whales (Van Bressem et al., 1999), but never neonatal calf mortality. It is not known if poxvirus occurs within the southern resident population. More information is needed about this virus and its occurrence in the southern resident population before its role in causing neonatal mortality can be determined. Attempts should be made to isolate the virus from "tattoo" or "ring" lesions found on dead southern resident killer whales and sympatric odontocetes, serum collected should be screened for antibodies to poxviruses, and poxvirus infection should be considered a differential diagnosis for all dead killer whale neonates and calves.

Due to the small size of the southern resident killer whale population and the gregarious social nature of these animals, introduction of a highly virulent and transmissible pathogen has the potential to catastrophically affect the long-term viability of the population. Porpoise and dolphin morbilliviruses are antigenically and genetically similar (Barrett et al., 1993) and are now generally considered strains of the same viral species, cetacean morbillivirus (Kennedy-Stoskopf, 2001). Although precise mortality rates are unknown for epizootics caused by these viruses, they have caused large-scale epizootics in bottlenose dolphins in the Western Atlantic (Lipscomb et al., 1994a) and the Gulf of Mexico (Lipscomb et al., 1996a), and in striped dolphins in the Mediterranean Sea (Forcada et al., 1994). Antibodies to morbilliviruses have been found in free-ranging common dolphins in the northeastern Pacific Ocean (Reidarson et al., 1998b), suggesting that these viruses may occur within the range of the southern resident killer whale population. It is not known if killer whales are susceptible to infection by cetacean morbillivirus. Cetacean morbillivirus infection may be enzootic among short-finned and long-finned (*Globicephala melas*) pilot whales in the western Atlantic Ocean (Duignan et al., 1995). Southern resident killer whales are sympatric with short-finned pilot whales. Cetacean morbilliviruses have a history of being highly virulent in some odontocete species, antibodies have been found in free-ranging common dolphins in the northeast Pacific Ocean, and short-finned pilot whales, a possible reservoir host for these viruses, could potentially transmit these viruses to southern resident killer whales. For these reasons, morbilliviruses represent a potential threat to the long-term viability of the southern resident killer whale population. If cetacean morbillivirus occurs or is introduced into the range of southern resident killer whales and if morbilliviruses prove to be highly virulent in killer whales, an epizootic within the population could have catastrophic

consequences and could threaten to the long-term viability of this population. Continued surveillance for antibodies to cetacean morbilliviruses in southern resident killer whales and sympatric odontocetes needs to continue, and morbillivirus infection must be considered a differential diagnosis in all dead southern resident killer whales.

Historically, herpesviruses were thought to cause cutaneous (Van Bressem and Van Waerbeek, 1996) and mucosal (Lipscomb et al., 1996b) lesions in odontocetes. More recently they have been documented to also cause severe encephalitis in harbor porpoises (Kennedy et al., 1992b; Blanchard et al., 2001) in the eastern Atlantic Ocean, and systemic disease in bottlenose dolphins (Blanchard et al., 2001) in the western Atlantic Ocean. Very little is known about the epidemiology of these viruses. Reports of herpesviruses causing fatal disease may represent recrudescence of latent infections, infection in immunologically naïve hosts, or atypical infections in aberrant hosts. Similar viruses have not been identified in the northeast Pacific Ocean, and there is no evidence that killer whales would be susceptible to infection by these viruses if they were present. However, because herpesviruses have been reported to cause severe disease in two species of free-ranging odontocetes and because of the infectious nature of these viruses, they may have the ability to cause large-scale mortality in the southern resident killer whale population. Surveillance for herpesviruses in odontocetes from the northeast Pacific Ocean needs to be started and continuing research on the epidemiology of these pathogens is warranted.

There are potential flaws in assuming that southern resident killer whales are equally susceptible to infection by pathogens known to cause epizootics in sympatric odontocete species. It is not known if pathogens that cause epizootics or severe disease in individual sympatric odontocete species will similarly affect killer whales. Conversely, we cannot be

certain that infectious agents in sympatric odontocete species classified as less virulent might not be more virulent in killer whales. High total polychlorinated biphenyls (PCB) concentrations in tissues of southern resident killer whales make them among the most contaminated cetaceans in the world (Ross et al., 2000). Although age may be a confounding factor, it has been suggested that there is an association between cetacean exposure to PCBs and mortality due to infectious diseases (O'Hara and O'Shea, 2001). For example, Jepson et al. (1999), found that harbor porpoises that died from infectious diseases had higher chlorobiphenyl concentrations than those that died from physical trauma. Also, it has been suggested that the high mortality seen in a morbillivirus epizootic in striped dolphins in the Mediterranean Sea may have been related to high PCB concentrations (Domingo et al., 1992; Aguilar and Borrell, 1994). If high PCB levels in southern resident killer whales increase host susceptibility to infectious agents, pathogens that are not documented to cause severe disease in other odontocete species may be more virulent in this population of killer whales.

Compared to some wildlife species, information about infectious diseases in free-ranging killer whales is sparse, making identification of potentially important pathogens difficult. Despite this, we were able to use the best available existing information about infectious diseases in killer whales and sympatric odontocete species to develop a list of potentially important infectious diseases for the endangered southern resident killer whale population. Although surveillance may identify previously undocumented pathogens, identified diseases will serve as a baseline for a standardized necropsy protocol and disease testing for stranded southern resident killer whales and sympatric odontocetes. Additionally, evaluation of identified infectious diseases targets four specific high priority infectious agents (marine *Brucella*, cetacean poxvirus, cetacean morbillivirus, and herpesviruses) that

warrant further study. Infectious disease risk assessments needs to be carried out for all threatened or endangered wildlife populations, even if there is limited information about infectious diseases in the species of concern.

Acknowledgements

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Figure 1: Southern resident killer whale mortality data by year (1976-2002; n=78 mortalities)

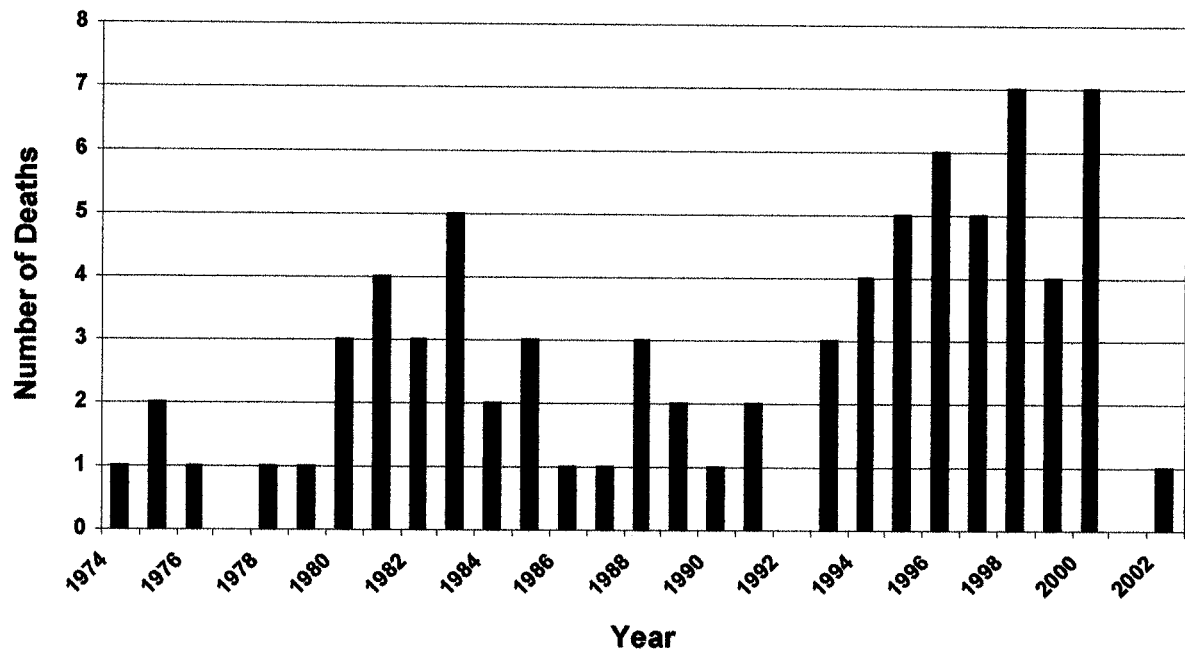


Figure 2: Southern resident killer whale mortality data by age class (1976-2002; n=78 mortalities)

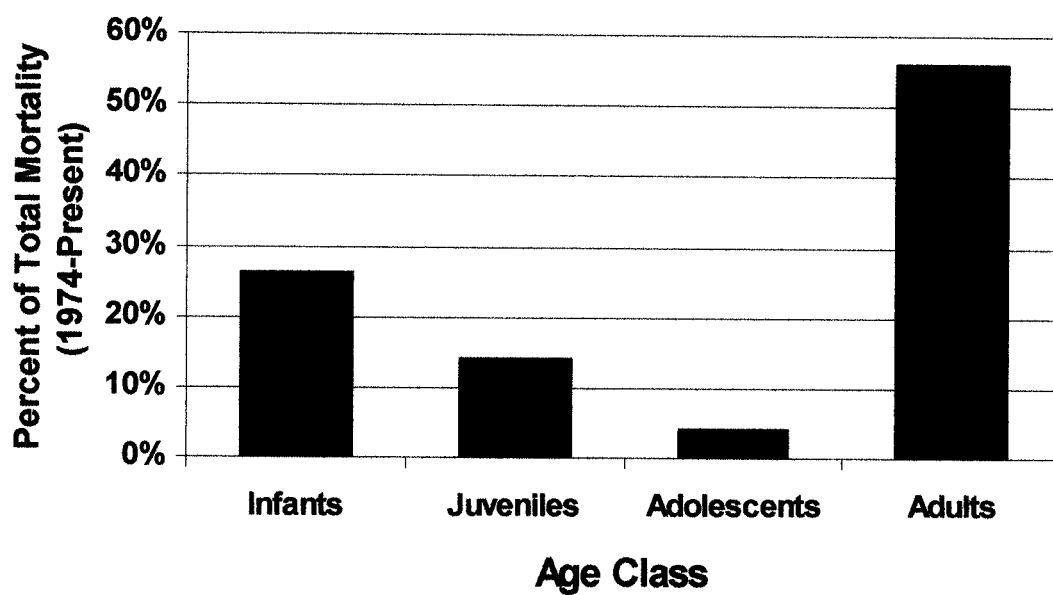


Figure 3: Southern resident killer whale infant mortality data by age class (1976-2002; n=16 mortalities)



Table 1: Infectious diseases reported in free-ranging killer whales

Pathogen	Reference	Virulence in individuals	Epizootic potential	Ability to reduce fecundity	Ocean
Bacteria					
<i>Brucella</i> spp.	Jepson et al., 1997	Low	Low	High	Northeastern Atlantic
Viruses					
Cetacean pox virus (Orthopoxvirus)	Van Briesem et al., 1999	Low - Adults High - Neonates	Low	Low	Not Reported

Table 2: Infectious diseases reported in captive killer whales

Pathogen	Reference	Virulence in individuals	Epizootic potential	Ability to reduce fecundity
Bacteria				
<i>Burkholderia pseudomallei</i>	Hicks et al, 2000	High	Low	Low
<i>Clostridium perfringens</i>	Walsh et al, 1994	High	Low	Low
<i>Erysipelothrix rhusiopathiae</i>	Bossart et al, 1988	Unknown	Unknown, likely low	Unknown, likely low
<i>Nocardia asteroides</i>	Sweeney et al, 1976	High	Low	Low
<i>Nocardia otitidiscaviarum</i>	Dunn et al, 2001	High	Low	Low
<i>Salmonella</i> sp.	Ridgway, 1979	High	Low	Low
<i>Streptococcus</i> sp., beta-hemolytic	Greenwood and Taylor, 1985	High	Low	Low
Viruses				
Hepatitis-B like virus	Bossart et al, 1990	Low	Low	Low
Influenza (suspected, no virus isolated)	Ridgway, 1979	High	Low	Low
Cutaneous papilloma virus	Bossart et al, 1996	Low	Low	Low
Fungi				
<i>Aspergillus fumigatus</i>	Reidarson et al, 1999	High	Low	Low
<i>Candida albicans</i>	Greenwood and Taylor, 1985; Ridgway, 1979; Sweeney et al, 1976	High	Low	Low
<i>Saksenaia wasiformis</i>	Reidarson et al, 1999	Unknown	Unknown, likely low	Unknown, likely Low

Table 3: Infectious diseases of free-ranging sympatric odontocete species not reported in free-ranging or captive killer whales

Pathogen	Species	Reference	Virulence in individuals	Epizootic potential	Ability to reduce fecundity	Ocean
Bacteria						
<i>Actinomyces bovis</i>	Bottlenose dolphin	Sweeney et al., 1976	High	Low	Low	Gulf of Mexico
<i>Helicobacter</i> sp.	White-sided dolphins	Harper et al., 2000	Unknown, likely low	Unknown, likely low	Unknown, likely low	Northwestern Atlantic
	Common Dolphin	Harper et al., 2000	Unknown, likely low	Unknown, likely low	Unknown, likely low	Northwestern Atlantic
<i>Vibrio alginolyticus</i>	Bottlenose dolphin	Buck and Spotte, 1986	Unknown	Unknown, likely low	Unknown, likely low	
	Striped dolphins	Buck and Spotte, 1986	Unknown	Unknown, likely low	Unknown, likely low	Northwestern Atlantic
<i>Vibrio parahaemolyticus</i>	Bottlenose dolphin	Buck and Spotte, 1986	Unknown	Unknown, likely low	Unknown, likely low	Not Reported
Viruses						
Herpesviruses	Bottlenose dolphin	Blanchard, et al., 2001	High	High	Low	Western Atlantic
	Harbor porpoise	Kennedy et al., 1992b	High	High	Low	Western Atlantic
	Harbor porpoise	Lipscomb et al., 1996b	Low	Low	Low	Western Atlantic
Morbillivirus, Dolphin	Bottlenose dolphin	Lipscomb et al., 1994a and b; Taubenberger et al., 1996; Van Bressem et al., 2001	High	High	High	Western Atlantic; Gulf of Mexico
	Striped dolphins	Domingo et al., 1992	High	High	High	Mediterranean Sea
	Short-finned Pilot whales	Duignan, 1995	High	High	High	Western Atlantic
	Harbor porpoise	Van Bressem et al., 2001	High	High	High	Northeastern Atlantic; North Sea
	Striped dolphin	Van Bressem et al., 2001	High	High	High	Mediterranean Sea
	Risso's dolphin	Van Bressem et al., 2001	High	High	High	Mediterranean Sea

	Common dolphin	Reidarson et al., 1998b	High	High	High	Northeastern Pacific
Morbillivirus, Porpoise	Harbor porpoise	McCullough et al., 1991; Visser et al., 1993	High	High	High	Northeastern Atlantic; North Sea
	Bottlenose dolphin	Taubenberger et al., 1996	High	High	High	Western Atlantic
	Common porpoise	Kennedy et al., 1992a	High	High	High	Eastern Atlantic
<u>Fungi</u>						
<i>Coccidioides immitis</i>	Bottlenose dolphin	Reidarson et al., 1998a	High	Low	Low	Northeastern Pacific
<i>Cryptococcosis neoformans</i>	Striped dolphin	Gales et al., 1985	High	Low	Low	South Pacific
<i>Loboa lobo</i>	Bottlenose dolphin	Caldwell et al., 1975	Low	Low	Low	Western Atlantic
<i>Rhizopus</i> sp.	Harbor porpoise	Wunschmann et al., 1999	High	Low	Low	Baltic Sea

Table 4: Infectious diseases of captive sympatric odontocete species not reported in free-ranging odontocete species nor in free-ranging or captive killer whales

Pathogen	Species	Reference	Virulence in individuals	Epizootic potential	Ability to reduce fecundity
Bacteria					
<i>Edwardsiella tarda</i>	Bottlenose dolphin	Sweeney and Ridgway, 1975	Low	Low	Low
<i>Nocardia brasiliensis</i>	Bottlenose dolphin	Sweeney et al., 1976	Unknown	Unknown, likely low	Unknown, likely low
<i>Nocardia caviae</i>	Bottlenose dolphin	Sweeney et al., 1976	Unknown	Unknown, likely low	Unknown, likely low
<i>Nocardia paraguayensis</i>	Bottlenose dolphin	Jasmin et al., 1972	Low	Low	Low
<i>Pasteurella hemolyticum</i>	Bottlenose dolphin	Sweeney and Ridgway, 1975	High	Low	Low
<i>Pasteurella multocida</i>	Bottlenose dolphin Common dolphin	Sweeney and Ridgway, 1975	High	Low	Low
<i>Pseudomonas pseudomallei</i>	Bottlenose dolphin	Sweeney, 1986	High	Low	Low
<i>Staphylococcus aureus</i>	Bottlenose dolphin	Ketterer and Rosenfeld, 1974	High	Low	Low
Viruses					
Caliciviruses	Bottlenose dolphin	Smith, A. W., 1983	Low	Low	Low
Fungi					
<i>Apophysomyces elegans</i>	Bottlenose dolphin White-sided dolphin	Reidarsen et al., 1999	Unknown	Unknown, likely low	Unknown, likely low
<i>Aspergillus flavis</i>	Bottlenose dolphin	Sweeney et al., 1976	Unknown	Unknown, likely low	Unknown, likely low
<i>Blastomyces dermatitidis</i>	Bottlenose dolphin	Cates et al., 1986	High	Low	Low
<i>Cladophialophora bantiana</i>	Harbor porpoise	Reidarsen et al., 1999	Unknown	Unknown, likely low	Unknown, likely low
<i>Histioplasma capsulatum</i>	Bottlenose dolphin	Jensen et al., 1998	High	Low	Low
<i>Mucor</i> sp.	Bottlenose dolphin	Sweeney et al., 1976	Unknown	Unknown, likely low	Unknown, likely low
<i>Sporothrix schenckii</i>	Pacific white-sided dolphin	Miyagi et al., 1978	High	Low	Low
<i>Trichophyton</i> sp.	Bottlenose dolphin	Hoshina and Sigiura in	Low	Low	Low

		Sweeney and Ridgway, 1975			
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